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Early Diagnosis of Alzheimer's disease using Electrochemical-based Nanobiosensors for miRNA Detection

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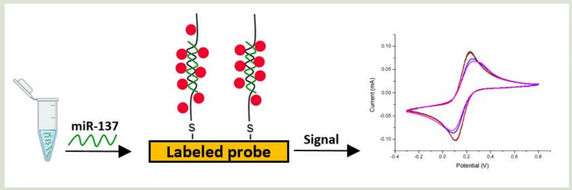
Introduction

Alzheimer's disease is an incurable neurodegenerative disorder and characterized by progressive memory loss and cognitive function deficits. In Alzheimer's, abnormal proteins accumulate inside and outside of the neurons, which disrupt the connection between neurons and eventually destroy certain neural cells. MicroRNAs (miRNAs) are a group of single-stranded non-coding RNAs with an average length of 22 nucleotides and are highly conserved. They effect on genes by binding to 3' untranslated region (3'UTR) of the target messenger RNA (mRNA) and regulate post-transcriptional gene expression. Because Alzheimer's is an untreatable disease, early diagnosis using reliable biomarkers is a promising way to control the disease in its early stages. In the onset of neurodegenerative diseases, an imbalance in microRNA expression has been proven, which plays an important role in the pathogenesis of these diseases. In recent years, the use of electrochemical nanobiosensors to measure circulating microRNAs as a potential biomarkers in neurological diseases has been increasingly developed due to their low cost, ease of production and use, fast response, good stability, and high sensitivity. Accordingly, electrochemical nanobiosensors have become attractive tools in the early detection of many diseases, including neurological diseases.

Methods

An electrochemical biosensor is usually made of a solid electrode with a single-stranded nucleotide probe or a complementary microRNA sequence on its surface and electroactive hybridization markers. Multiple carbon nanotubes (MWCNTs), gold nanoparticles (AuNPs), and graphene oxide (GO) are commonly used to increase surface area and electrical conductivity. In case of Alzheimer's, a thiol probe with the miR-137 complementary sequence, a reliable biomarker for Alzheimer's detection, can be used. For this purpose, the complementary nucleotide sequence of miR-137 should be exposed to an electrode coated with nanoparticles.

Figure #1



Schematic illustration of fabrication the electrochemical nanobiosensor.

Results

The use of nanomaterials in biosensors improves stabilization, detection methods, and the sensitivity of biosensors. Due to the high affinity of the thiol groups (–RSH) to nanoparticles, especially AuNPs, functionalized AuNPs with specific oligonucleotide sequence are more stable and have a stronger binding affinity to their complementary nucleic acid sequences. After the modified nanobiosensor is exposed to a clinical sample, hybridization would occur in the presence of the target microRNA (in this case, miR-137). Under these conditions, the hybridization process is converted into a measurable signal using electrochemical techniques.

Conclusions

To date, there is still no cure for neurodegenerative diseases and no gold standard diagnostic method has been defined for them. MicroRNA-based biosensors have become promising devices due to their many useful properties, including high stability, good sensitivity, and easy production process at low cost for detecting these diseases in the early stages, especially Alzheimer's. Previous studies to make a nanobiosensors for microRNA detection in Alzheimer's have demonstrated the effectiveness of these biosensors in measuring real clinical samples and have made them as a potential tool for early diagnosis of this disease.

Bibliography

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